Effects of Tall Man Lettering and Position in Discriminating Confusable Drug Names

by

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ABSTRACT

Medical errors are now estimated to be the third leading cause of death in the United States (Makary & Daniel, 2016). Look-alike, sound- alike prescription drug mix-ups contribute to this figure. The US Food and Drug Administration (FDA) and Institute for Safe Medication Practices (ISMP) have recommended the use of Tall Man lettering since 2008, in which dissimilar portions of confusable drug names pairs are capitalized in order to make them more distinguishable. Research on the efficacy of Tall Man lettering in differentiating confusable drug name pairs has been inconclusive and it is imperative to investigate potential efficacy further considering the clinical implications (Lambert, Schroeder & Galanter, 2015). The present study aimed to add to the body of research on Tall Man lettering while also investigating another possibility for the mechanism behind Tall Man's efficacy, if it in fact exists. Studies indicate that the first letter in a word offers an advantage over other positions, resulting in more accurate and faster recognition (Adelman, Marquis & Sabatos-DeVito, 2010; Scaltritti & Balota, 2013). The present study used a 2x3 repeated measures design to analyze the effect of position on Tall Man lettering efficacy. Participants were shown a prime drug, followed by a brief mask, and then either the same drug name or its confusable pair and asked to identify whether they were the same or different. All participants completed both lowercase and Tall Man conditions. Overall performance measured by accuracy and reaction time revealed lowercase to be more effective than Tall Man. With regard to the position of Tall Man letters, a first position advantage was seen both in accuracy and reaction time. A first position advantage was seen in the lowercase condition as well, suggesting the location of the differing portion of the word matters more than the format used. These findings add

to the body of inconclusive research on the efficacy of Tall Man lettering in drug name confusion. Considering its impact on patient safety, more research should be conducted to definitively answer the question as to whether or not Tall Man should be used in practice.

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CHAPTER 1

INTRODUCTION

Medical errors are on the rise. In fact, a staggering publication from researchers at Johns Hopkins University School of Medicine estimate medical errors to be the third leading cause of death in the United States (Makary & Daniel, 2016). Prescription drug errors have contributed to this figure, to include medication mix-ups of similar drug names. In 2001, the US Food and Drug Administration (FDA) Office of Generic Drugs launched the Name Differentiation Project, which asked manufacturers of 16 pairs of look-alike drug names to implement Tall Man lettering in an effort to minimize confusion (Food and Drug Administration, n.d.). Tall Man lettering capitalizes the dissimilar portions of confusable drug names in attempt to reduce medication errors. In 2008, the ISMP published “FDA and ISMP Lists of Look-Alike Drug Names with Recommended Tall Man Letters,” an unofficial list of confusable drug name pairs with a recommended bolded Tall Man lettering format (Institute for Safe Medication Practices, 2008). This list has been updated several times, most recently in June 2016 (Institute for Safe Medication Practices, 2016).

CHAPTER 2

LITERATURE REVIEW

Text Enhancements

Text enhancements, such as Tall Man lettering, should exaggerate the differences between two words in order to identify a mismatch (Schell, 2009). One possible advantage of text enhancements such as Tall Man lettering is that it adds perceptual characteristics to provide additional information necessary when differentiating two similar words. Enhanced letters should be the most salient, and the first letters compared, when comparing drug names in a display sequence. However, real world time constraints may not allow pharmacists and other medical professionals to perceive each letter in a word equally or devote enough time to perceive each letter in the word to begin with. Additionally, enhancing the dissimilar portions of a word could result in lower perceptual processing of the rest of the word. This could be detrimental, as some confusable drug pairs have dissimilarities in more than one part of the word. For example, the confusable drug pair azaTHIOprine and aziTHROmycin have differences in all parts of the word, thus detracting attention from the unenhanced letters could be dangerous if they too possess cues that can assist the person trying to make the distinction. Even if a pair of drug names possess only one area of difference, enhancing these portions could create confusion with other drug names outside of the pair.

Support for or against the use of Tall Man lettering in reducing drug name confusion may rest on which theory of word perception one subscribes to. If one uses bottom-up processing and perceives words as letter strings (letter-word perception), enhancing letters could be useful. However, if a top-down approach is utilized (word-letter perception), enhancing letters may not be helpful and could potentially result in worse performance. If words are perceived word as a whole, enhancing text can make the text appear more similar and be difficult to differentiate.

Tall Man Lettering

Tall Man lettering aims to attract attention to the dissimilar aspects of confusable drug names by capitalizing the differentiating letters. The ISMP list follows the CD3 rule whenever possible in order to encourage standardization. However, there are instances in which the CD3 rule does not make the words easier to distinguish and can actually make them more confusing (Institute for Safe Medication Practices, 2016). In fact, there are several variations of Tall Man to include: Mid Tall Man, CD3 Tall Man, and Wild Tall Man. Each variation has its own set of rules, as described in pages 24-25 of Darker, Gerret, Filik, Purdy & Gale (2011):

"The Mid Tall Man rule: collect drug names into groups of two or more names that are orthographically similar (these groupings were determined in consultation with experts at the National Patient Safety Agency and the NHS Connecting for Health Initiative); on a letter-by-letter basis, start from either end of each drug name in a confusable group and work towards the middle; capitalise the first letters encountered at either end that differ across at least two drug names in the group, along with all letters occurring between them. Essentially, the entire critical portion of the drug name is capitalised, for example, cefixime, cefotaxime, ceftazidime and cefuroxime would become cefIXime, cefOTAXime, cefTAZIDime and cefUROXime.

The CD3 Tall Man rule: collect drug names into groups and define the critical portions in the same way as for the Mid Tall Man rule, but capitalise a maximum of only three letters per drug name. Where more than three letters are present in the critical portion of the drug name, capitalise the centre most three. Where this would result in letters that are common amongst all the drug names of the group in those positions being capitalised, then capitalise the next most peripheral letters that differ across at least two drug names. In order to prevent confusion with a lowercase letter ‘l’, the letter ‘i’ is not capitalized unless it is the initial letter of a proprietary drug name. Using the CD3 rule, cefixime, cefotaxime, ceftazidime and cefuroxime would become cefiXime and cefOTAxime, cefTAZidime and cefUROxime.”

The Wild Tall Man format does follow have any consistent rule, however is comprised of existing examples of Tall Man implementations (Appendix D).

Mid Tall Man	**CD3 Tall Man**	**Wild Tall Man**
azATHIOPRINE azITHROMYCIN	cefOTAxime cefiXime	azaTHIOprine aziTHROmycin

Figure 1. Tall Man Lettering Variations

Theoretical Support for Tall Man Lettering

Word Superiority Effect

Reicher (1969) presented stimuli consisting of one or two individual letters, four-letter words, and four-letter nonwords briefly in a tachistoscope, followed by a masking field with two individual letters serving as response alternatives. Participants were asked to choose which letter alternative matched what was shown previously. Overall, letters were identified more accurately when first shown a word rather than a single letter. When asked, the majority of participants (8 of 9) stated they perceived words as word units and not as their individual letters. Wheeler (1970) replicated this study and also found that words were perceived more accurately by approximately 10%. These widely cited studies show the Word Superiority Effect, that words provide a context of meaning that enable individual letters to be more easily recognized. The Interactive Activation Model is a potential explanation for the Word Superiority Effect (McClelland & Rumelhart, 1981). This model is based on multiple levels of processing. In the context of word perception, this occurs at the visual feature level, letter level, and word level, with higher top-down processing also occurring at the word level. These levels are processed simultaneously in multiple letters. Perception is driven by excitatory and inhibitory interactions at the visual feature, letter, and word levels. When viewing a word, detectors are activated for the features of those letters, letters, and words. A word is more easily perceived because more activations occur compared to letters and letter features.

The Word Superiority Effect provides support for the Word Shape Model, which postulates that since words are perceived as units and not individual letters, the outline or shape of the word is what enables people to recognize words (Bouwhuis & Bouma, 1979). However, the Word Shape Model does not support several findings on Tall Man Lettering that yielded results no greater than performance with words presented in entirely in lowercase (Schell, 2009) and uppercase (Darker et al, 2011). Tall Man can result in a more similar word shape, especially in cases where large portions of the drug name are capitalized. If the Word Shape Model does not explain the use of Tall Man lettering, other models should be investigated to identified any possible mechanisms underlying Tall Man efficacy, if it exists.

Models of Letter Processing

Research has indicated that letters in words are perceived simultaneously rather than sequentially from left to right (Rumelhart & McClelland, 1982; Tydgat & Grainger, 2009; Adelman, Marquis, & Sabatos-DeVito, 2010). Adelman et al. suggest that the identification of each letter begins at the same time, however attention or efficiency can decrease as letters progress from left to right. Such letter level phenomena are acknowledged within the simultaneous model of letter processing, and have been attributed to the attentional characteristics of letter detectors that result in different levels of signal strength throughout letter processing (Rumelhart & McClelland; Tydgat & Grainger). Adelman et al. investigated whether the left to right decrease in accuracy was due to attentional or efficiency degradation.

First Position Advantage

Research has found a significant first position advantage in letter processing within a word, in which the first letter of a word is recognized faster and more accurately compared to subsequent letters. Adelman, Marquis, and Sabatos-DeVito (2010) presented four-letter words briefly in eight brief durations ranging from 12-54 ms and asked participants to choose one of two alternatives, either the same word or a word with one letter changed. Accuracy improved when the display time increased, and critical display duration was identified in the 18-24 ms timeframe. At 18 ms participants performed at chance, however 6 added ms provided enough time for performance to surpass that of chance, regardless of the position in question. Essentially, no information was taken from any of the four letters when the word was shown for 18ms, but some information was extracted from all four letters when show for 24ms. This careful analysis revealed that initiation of letter identification occurred simultaneously, specifically when lower level information presents itself sometime between 18-24 ms. This finding negates the sequential model of letter processing that suggests words are read letter by letter from left-to-right, each letter taking 10-25 ms to process before moving on to the next. Words with changes to the first letter were identified more accurately compared to words with letter changes in the second, third, and fourth positions. Accuracy declined in positions from left to right.

The first position advantage was replicated in a robust series of four experiments conducted by Scaltritti and Balota (2013), in which changes to the first letter in words, legal nonwords, and random consonant strings were recognized more accurately and quickly compared to letter changes in all other positions. The first position advantage persisted in words of varying lengths, and when word length was blocked and randomly mixed.

Research on Tall Man showing Efficacy

Tall Man lettering is one way to enhance text and draw attention to the dissimilarities between confusable drug names. Filik, Purdy, Gale, & Gerrett (2004) found Tall Man lettering to be effective in reducing drug name confusion when performing a visual search task. Non-healthcare professionals were shown a mock drug pack with a target drug name printed in either lowercase or Tall Man. The drug pack image had shading to make it appear three dimensional and contained drug information such as dosage, form (e.g. capsules, tablets), the statement “Patient Pack 28” printed on the bottom left, and a vertical colored strip on the left side to simulate a packaging design. Confusable drug pairs had drug packs containing identical information except the drug name itself. A brief mask and fixation point were displayed following the target drug pack. Participants were then asked search for the target drug pack in an array of 20 drug packs, which consisted of 19 low similarity drug name packs and one pack containing the confusable, highly similar drug name. Throughout the trials the confusable drug name pack would be shown in each of the 20 positions throughout the array. The target drug name was never displayed in any of the packs in the array during the experiment, only its corresponding, confusable drug name pair. In order to prevent participants from realizing the target drug name pack was never featured in the array, 20 filler trails were shown containing matches. Half of the packs in the array featured drug names in Tall Man and half in lowercase. Each drug name had two stimulus files and was presented in both Tall Man and lowercase, however participants saw a drug name only once. Participants made significantly less errors when the Target drug names pack featured Tall Man lettering. When the target drug pack was in lowercase, participants would incorrectly identify the confusable drug name pack in the array as the target drug pack. This task corresponded to looking for a drug on a shelf, which has been identified as a point for drug errors in practice.

Filik et al. (2010) found additional support for the use of Tall Man lettering in two experiments that featured both older adults and a larger sample size of healthcare professionals. In Experiment 1 both young and older adults were given a same/different judgment task, similar to Schell (2009) in which they were shown a drug name, followed by a mask, and presented either the same drug name or its confusable pair. Participants were either shown the same drug name twice, or a confusable drug pair. This was repeated in both Tall Man and lowercase format, resulting in four conditions: lowercase/same, lowercase/different, Tall Man/same, Tall Man/different). Drug names in Tall Man resulted in significantly less errors (reporting that the two drugs were the same) compared to drug names in lowercase. In addition, it took participants longer to respond to different drug pairs in lowercase compared to Tall Man, indicating that Tall Man letters are perceived first and aids in discriminating between the two. Conversely, when two drug names were the same, participants took longer to respond to the Tall Man compared to lowercase. If the Tall Man letters are perceived first and they appear the same, the participant needed to scan the rest of the word to find whether or not other differences exist. It can be concluded that participants looked at entire word and did not rely on the Tall Man letters for making a determination. In Experiment 2, healthcare personnel were shown a drug name, followed by a mask, and asked whether or not it was present in a list of names. Tall Man formatting resulted in fewer errors and faster response times compared to those presented in lowercase.

Research on Tall Man not showing efficacy

Schell (2009) investigated the effect of text enhancement on the recognition of drug names in two studies using laypersons and pharmacy staff. Both experiments utilized a sequential task in which the prime stimulus drug name was shown, followed by a brief mask, and then shown the target stimulus drug name. Among laypeople, drug names presented in Tall Man format led to significantly more errors compared to drugs presented in lowercase or color-based text enhancement. The errors included participants incorrectly identifying two drugs as different when they were the same, and incorrectly identifying two different drugs as being the same. When studied among pharmacy personnel, no significant differences in performance were seen between Tall Man lettering and other case enhancements or in Tall Man compared to those in lowercase.

Filik, Purdy, Gale, & Gerrett (2006) conducted three experiments investigating the efficacy of both Tall Man lettering and color on confusable drug names. The first two experiments employed a same/different judgment task in which participants had to decide as quickly and accurately as possible whether or not two drug names presented side-by-side on a computer screen where the same or different. Drug names pairs were presented in either lowercase or Tall Man format, and each format featured pairs that were the same and different. The task was measured by response time as it was seen as a measure of task difficulty. That is, if Tall Man lettering made the task easier to perform it should result in a faster response time. In both experiments participants took longer to identify two words that were the same compared to when they were different, suggesting it is easier to detect differences in the words compared to scanning the entire words in order to determine two names as being the same. There were no differences in response times between lowercase and Tall Man formats when participants went into the experiment not knowing the goal of Tall Man lettering on drug name confusion (Experiment 1). However, when participants were told the goal of Tall Man lettering prior to the task it resulted in faster response times compared to the lowercase condition (Experiment 2). Prior to Experiment 3 participants were asked to subjectively rate different format enhancements including Tall Man, size (larger lowercase), color (red), italics, underlining and boldface. Word pairs presented in lowercase without any manipulation were rated as most confusing. Word pairs with sections of red text were perceived as least confusing, so it was the enhancement chosen for Experiment 3.

Experiment 3 employed a recognition memory task in which participants were asked to remember a list of drug names and then shown another list of drug names containing some of the same drug names mixed in with their confusable drug name (Filik, Purdy, Gale, & Gerrett, 2006). The task simulated the practical application in which a pharmacist looks for a specific drug name on a shelf among other similar drug names. Names containing Tall Man lettering were recognized more accurately than those presented in lowercase. The use of red letters did not have a significant effect on the recognition rate, and when combined with Tall Man lettering did not product better results than Tall Man lettering alone. Tall Man letters resulted in less false negative errors (false alarms), however did not significantly impact the prevalence of false positive errors (mistaking the confusable drug name for the target drug name). The results indicate that Tall Man letters may be useful in drawing attention to highly similar drug names, but does not necessarily make them less confusable when recalling from memory. These results did not support the use of Tall Man letter or colored enhancements in the practical application of reducing medication errors.

Darker et al. (2011) employed a forced-choice task in which a stimulus drug name was presented briefly, followed by presentation of both the stimulus drug name and confusable drug name. Drug names with Tall Man lettering performed no better than drug names presented in uppercase. Consequently, it may be possible that capital letters alone may help perceive differences between similar words, regardless of what letters they are.

One possible explanation for this is that uppercase letters are more legible than lowercase letters (Tinker, 1963) due to their increased size (Sheedy et al., 2005). Uppercase letters may provide enough of a perceptual advantage on their own to drive the effect seen in drugs with Tall Man letters, rather than the contrast of the uppercase and lowercase letters. The argument for uppercase letters is supported in Darker et al.'s (2011) findings in which higher accuracy was achieved with Mid Tall Man compared CD3 Tall Man. Mid Tall Man capitalizes all letters that differ between two similar drug names, whereas CD3 Tall Man only capitalizes a maximum of three letters. The Mid Tall Man results in more capital letters in the majority of cases (75%). It should be noted that there was no significant difference in accuracy between Mid Tall Man and uppercase, suggesting that capitalizing letters outside of the critical portion does help in the identification of a drug name.

It is evident that research on the efficacy of Tall Man Lettering on drug name confusion is inconclusive. DeHenau, Becker, Bello, Liu, & Bix (2016) tested the efficacy of Tall Man lettering when several stimuli compete for one's attention. Participants included both laypeople and healthcare providers. A change detection task was implemented by presenting a standard image, followed by a brief gray screen, and then a test image. Participants were asked to detect the change made to the standard image by pressing the space bar, and clicking the mouse on the location that was changed. The standard and test images were presented in a 4x4 grid of drug labels consisting of brand name, brand symbol, Rx status, route of administration and concentration. Only one drug name was changed to its confusable alternative in the array of 16 labels. Drug name pairs were either presented in Tall Man format or lowercase format. Results showed higher change detection rates in confusable drug name pairs presented in Tall Man lettering compared to traditional format for both healthcare workers and laypeople. Change detection time was also faster for Tall Man format in both laypeople and healthcare workers. Laypersons were more likely than healthcare workers to detect a change. This difference between test groups may be explained by an age effect, as the layperson group was younger overall.

Zhong et al. (2016) used pediatric pharmacy data from 42 children's hospitals between 2004-2012 to test the effect of Tall Man lettering in practice. Using the published lists of LA-SA drugs from the ISMP, FDA, and Joint Commission, a list of 76 look alike sound alike (LA-SA) drug name pairs was derived. The list was further reduced by selecting only those medications that were both pertinent to pediatric patients and easily confused when presented in practice, as identified by two pediatricians and one pharmacist. Ultimately, a list of 12 confusable drug pairs was selected for further analysis. Only generic names were analyzed in this study.

The drug errors were classified into eight patterns over a four-day period, in which a transition of one drug (Drug A) to its LA-SA drug (Drug B) took place with either no overlap or a one-day overlap of both medications being dispensed in the same day (Zhong et al., 2016). Two of the eight patterns included another transition back to the original drug (Drug A, Drug B, Drug A). The longitudinal effects of Tall Man lettering implementation were analyzed using segmented regression analysis. Of the 12 confusable pairs identified above, one pair did not show any potential errors (doxazosin-warfarin) and was not analyzed further. The rate for the 11 LA-SA drug pairs ranged from 0 to 2.9 per 1000 hospitalizations. This yielded no statistically significant effects of Tall Man implementation on drug error rates of the 11 LA-SA drugs when analyzed individually or as a group. Further, no significant changes were identified after 2007, despite this being the year Tall Man was widely implemented.

The research of Zong et al. (2016) is critical in our understanding of Tall Man lettering efficacy for several reasons. First, it was a longitudinal study that spanned eight years analyzing the effect of Tall Man lettering before and after its widespread implementation. Second, it used pharmacy specific data to detect potential error rates. Last, it was able to go beyond theoretical laboratory studies to investigate Tall Man in practice. However, there were several limitations to this study that should be noted. The data was limited to pediatric patients with a hospital stay of 4 days or longer. Second, only data captured in the Pediatric Healthcare Information System (PHIS) were used to derive the LA-SA word pair list. Another limiting factor was that brand names were changed to generic names due to PHIS only using generic names. This resulted in some word pairs not being less confusable (fluoxetine-tacrolimus). Last, although Tall Man and other text enhancements were recommended widely in 2007, no formal implementation was required. Thus, it is difficult to know when and how such implementation occurred.

Lambert, Schroeder, & Galanter (2015) conducted a review Tall Man research and outlined the inconsistencies in results. One contention involves the methodologies used in the research. Another is whether result attribution actually belongs to the use of Tall Man lettering. In addition, most of the research has been conducted in the lab and even this research is conflicting. It is suggested that some of the supporting results are a result of demand characteristics, or participant knowledge of the task and expected behavior. Table 1 (Lambert, Schroeder, & Galanter, 2015 p. 215) outlines inconsistencies in previous published experiments on the efficacy of Tall Man lettering.

Table 1

Summary of published experiments examining the efficacy of Tall Man lettering in drug name confusion. Reproduced from 1 (Lambert, Schroeder, & Galanter, 2015 p. 215).

Table 1 Published laboratory-based experiments evaluating the impact of Tall Man lettering on look-alike/sound-alike drug errors

Author(s) and year of study	Number and type of participants	Type of laboratory-based experimental task	Were participants informed of the purpose of Tall Man lettering before the task?	Was there an effect of Tall Man lettering on drug name confusion errors?	Was there an effect of Tall Man lettering on other measures?	Was there an effect of degree of drug name similarity on errors or other measures?
Filik *et al* (2004)[15]	20 Lay people	Visual search	Unknown	Yes	Yes	–
Filik *et al* (2006)[16] Experiment 1	20 Lay people	Same–different	No	–	No	–
Filik *et al* (2006)[16] Experiment 2	20 Lay people	Same–different	Yes	–	Yes	–
Filik *et al* (2006)[16] Experiment 3	28 Lay people	Recognition memory	Unknown	No	Yes	–
Schell (2009)[28] Experiment 1	102 Lay people	Same–different	Unknown	No*	–	Yes
Schell, 2009[28] Experiment 2	11 Healthcare professionals	Same–different	Unknown	No	–	–
Filik *et al* (2010)[29] Experiment 1	56 Lay people	Same–different	Unknown	Yes	Yes	–
Filik *et al* (2010)[29] Experiment 2	127 Healthcare professionals	Visual search	Unknown	Yes	No*	–
Darker *et al* (2011)[18]	144 Healthcare professionals	Reicher–Wheeler	Yes	Yes	–	–
Irwin *et al* (2013)[19] Experiment 1	60 Lay people	Visual search	No	No	No	–
Irwin *et al* (2013)[19] Experiment 2	28 Healthcare professionals	Visual search	No	No	No	–
Or and Chan, (2014)[23]	60 Lay people and healthcare professionals	Same–different	Unknown	Yes	No	Yes
Or and Wang (2014)[24] Experiment 1	40 Lay people	Same–different	Unknown	Yes	–	Yes
Or and Wang (2014)[24] Experiment 2	40 Healthcare students	Same–different	Unknown	Yes	–	Yes
DeHenau *et al* (2016)[30]	40 Healthcare professionals, 40 Lay people	Flicker change detection	Unknown	Yes	Yes	–

*There was a significant effect but in the opposite direction (worse performance for Tall Man relative to standard text).

The Current Study

The present study aims to contribute to the empirical evidence for the efficacy of Tall Man lettering on drug name confusion. Since the results thus far have been inconclusive, we felt it was important to replicate some of the methods used to make this determination. The current study analyzes the effect of position on Tall Man lettering efficacy. It was predicted that drug names presented in Tall Man, regardless of position, would be discriminated more accurately and quickly than drug names presented in lowercase (H-1). It was also predicted that drug names whose differences occurred in the beginning of the word would be discriminated more accurately and more quickly than drug names with differences in the middle or end of the word (H-2).

CHAPTER 3

METHOD

Participants

A power analysis was generated with Gpower using an effect size F= 0.25, α =.05, 1– β = 0.95 with two conditions, indicated a total of 30 participants be used in this design (Faul, Erdfelder, Lang, & Buchner, 2007). Participants were recruited online utilizing Arizona State University's SONA system. The study required one session of approximately 45 minutes. Participants received course credit for participation in this study.

Materials

The confusable drug name pairs were taken from the Food and Drug Administration (FDA) and the Institute for Safe Medication Practices' (ISMP) FDA and ISMP Lists of Look-Alike Drug Names with Recommended Tall Man Letters (FDA & ISMP, 2011). Drug names were categorized based on the location of Tall Man lettering within the drug name. Three stimuli groups were formed based on whether Tall Man letters were located in the Beginning, Middle, or End of the drug name.

In order to control for the location of the differing portions of each drug name pair, we ensured both drug names in a pair had the same number of lowercase letters, for example DAUNOrubicin and DOXOrubicin. The FDA and ISMP recommended CD3 Tall Man format was followed as closely as possible when creating the three stimuli groups, however slight deviations were made in order to create equal numbers of stimuli for each group. For example, the FDA and ISMP recommended Tall Man lettering for the pair hydrALAZINE and hydrOXYzine changed to hydrALAzine and hydrOXYzine. A full listing of the stimuli can be referenced in Appendix C. The confusable word pair Norman-Norbert used in the four practice trials came from Schell's (2009) study. The experiment was collected using Inquisit software Version: 4.0.9.0 64bit (build 2657) (Inquisit 4, 2015). The study was implemented utilizing Inquisit Web Version: 5.0.7.0 (Inquisit 5, 2016).

Design

This study utilized a 2x3 repeated measures design. There were two independent variables: letter format and position. Letter format has two levels: lowercase and Tall Man:

Lowercase: All letters are lowercase. For example, "bupropion."

Tall Man: Only the differentiating letters of the drug name are capitalized, as indicated by the FDA. For example, "buPROPion."

The second independent variable of position has three levels: Beginning, Middle, and End:

Beginning: Differing portion is located in the beginning of the drug name. For example, "DOPamine."

Middle: Differing portion is located in the middle of the drug name. For example, "buPROPion."

End: Differing portion is located in the end of the drug name. For example, "predniSONE**.**

There are two dependent variables: reaction time and percentage of errors made in each condition. There were nine confusable drug name pairs for each position. Each confusable drug name pair had four trials to include two matches and two mismatches, as displayed in Table 2 below.

Table 2

Four combinations were derived for each confusable drug name pair.

Drug A	Drug B
Drug B	Drug A
Drug A	Drug A
Drug B	Drug B

Prime drug names were shown in Arial 14 point font. Target drug names following the 3 second mask were presented in Arial 14 point font in either lowercase or Tall Man lettering. For example, “bupropion” or “buPROPion.” Darker et al. (2011) found Arial 12 point font to be most commonly used in electronic prescribing software.

Procedure

Participants read the informed consent and clicked Continue to provide consent and proceed to the study. A brief demographic survey was completed, followed by an overview of the task and instructions (Appendix A). This study replicated the methodology from Schell (2009) as closely as possible. Participants were first shown an asterisk (*) for 3 seconds to orient their eyes to the center of the screen. This was immediately followed by the prime drug name for 400ms, a row of x's serving as the mask (XXXXXXXX) for 3 seconds, and finally the target name was presented (Figure 1).

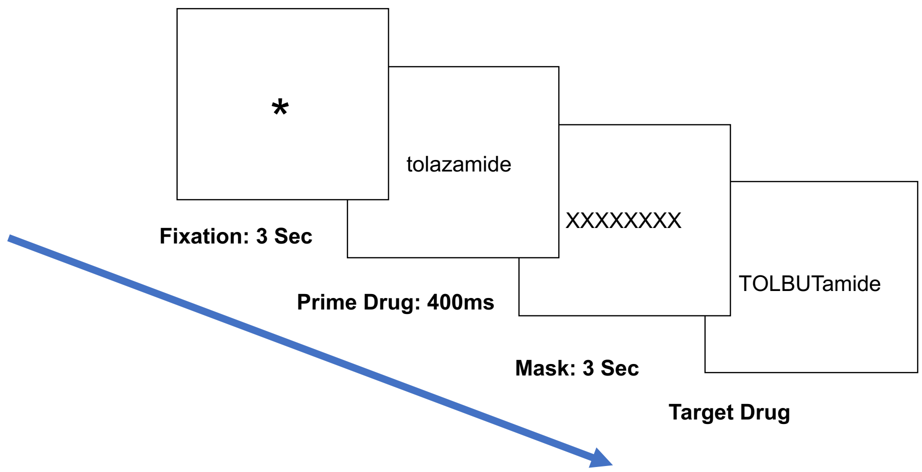

Figure 1. Diagram illustrating the experimental sequence.

Participants were asked to press E if the two drugs are different and I if they were the same. We asked the participants to go as fast as they could while making as few mistakes as possible since this was a reaction time task. Participants completed four practice trials (two matches and two mismatches) consisting of the confusable word pair Norman and Norbert (Schell, 2009). Screen shots of a practice trial sequence can be seen in Figures 2a-2e.

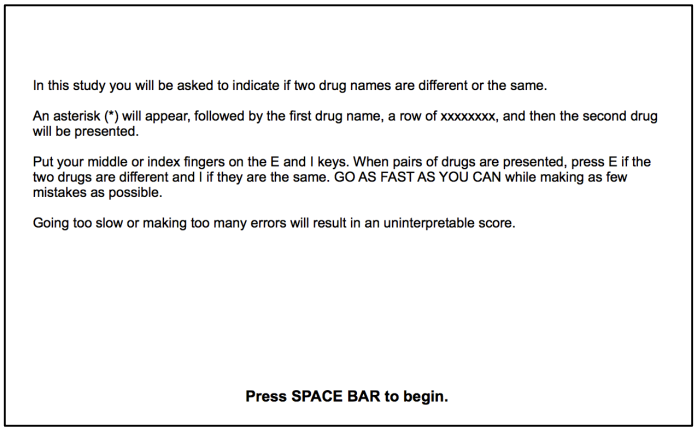

Figure 2a. Instructions

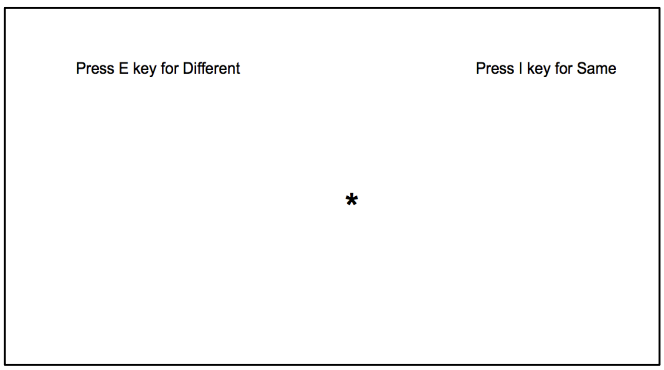

Figure 2b. Fixation (3 sec)

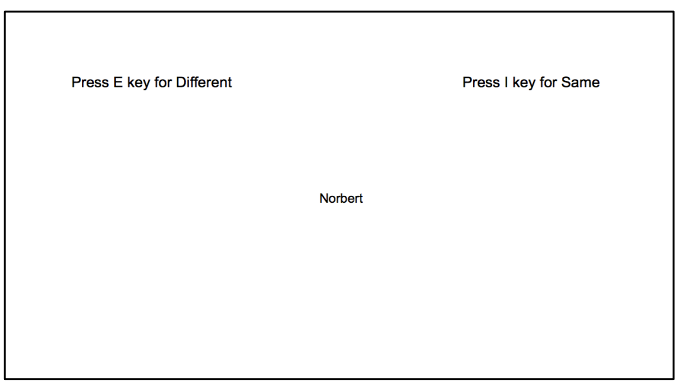

Figure 2c. Prime Drug Name (400 ms)

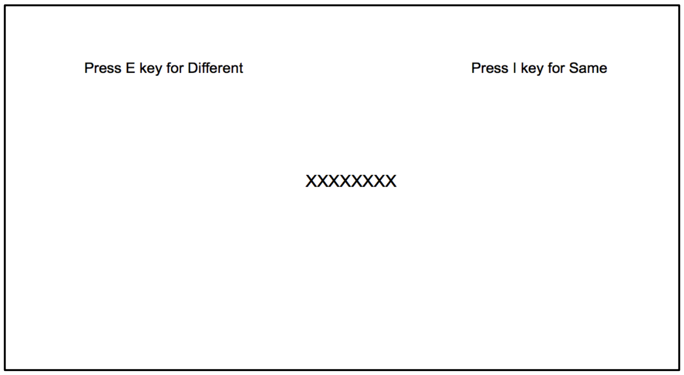

Figure 2d. Mask (3 sec)

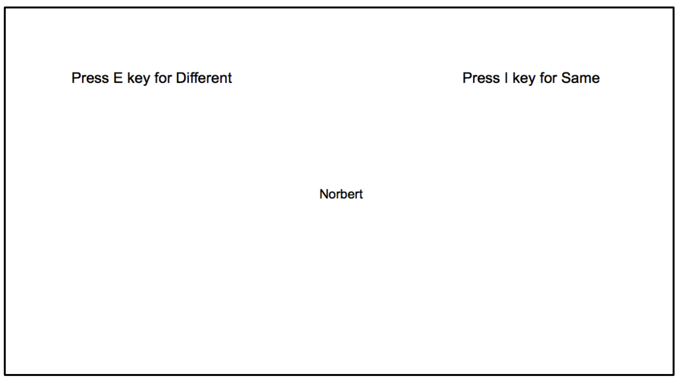

Figure 2e. Target Drug Name

Each condition had 108 trials and participants completed both and lowercase and Tall Man conditions, totaling 216 trials per participant excluding the four practice trials. The order of the conditions was counterbalanced to reduce any potential priming effect. The trials within each condition were also randomized. At the end of the study, participants were debriefed (Appendix B) and given credit for completion of the study.

CHAPTER 4

RESULTS

Accuracy

Drug names presented in lowercase were discriminated more accurately (M=0.82, SD=0.09) than those presented in Tall Man (M=0.78, SD=0.11, F(1,29)= 6.4, p=.017). Additionally, an ANOVA revealed a significant effect of accuracy on position, F(2,58)= 7.1, p=.002. Specifically, drug names with differences occurring in the beginning of the drug name were discriminated more accurately drug names with differences in other positions (see Figure 3). There was no interaction between Text Enhancement and Position.

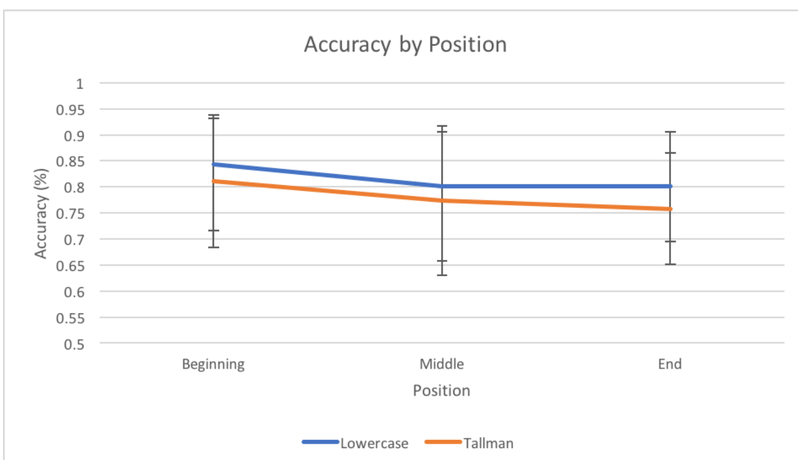

Figure 3. Line chart displaying mean accuracy percentages by position.

Reaction Time

Mean reaction times are presented in Figure 4. Drug names in lowercase (M=1119.71, SD= 348.90) were discriminated faster than drug names in Tall Man, (M= 1341.58, SD= 587.73; F(1, 29)= 7.4, p=0.011). Further, a one-way repeated measures ANOVA revealed a significant effect of position on reaction time, F(2, 58)= 7.9, p=0.001. Specifically, t-tests with Bonferroni correction revealed that drugs with differences in the beginning of the name (M=1162.23, SD=72.00) were discriminated faster than drugs with differences in the middle of the name (M=1289.65, SD= 90.40) and drug names with differences at the end (M=1244.09, SD=78.27.

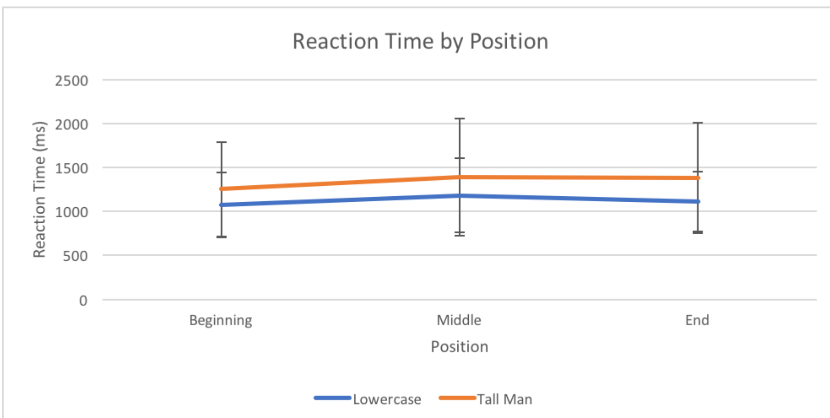

Figure 4. Line chart displaying mean reaction times by position.

CHAPTER 5

DISCUSSION

Overview of the Present Study

This study aimed to add to the body of Tall Man literature to help determine whether or not it is effective in differentiating confusable drug names. In order to better understand the underlying mechanism of Tall Man lettering, we tested the use of Tall Man letters in the beginning, middle, or end of a drug name. The results indicated that drug names for which the differences are capitalized in the beginning are discriminated more accurately and more quickly compared to the other locations. However, this effect of location was also seen in the lowercase condition in which nothing is differentiated, leading us to conclude that the Tall Man lettering was not the reason behind the effect. In addition, words presented in lowercase were discriminated more accurately and more quickly than in the Tall Man format. These results are in line with the previous publications on the variety of outcomes seen when empirically testing Tall Man lettering (Lambert, Schroeder, & Galanter 2015).

Strengths of the Present Study

There were several strengths to the current research that should be noted. First, we aimed to replicate several elements of the methodology used in Schell (2009); the timing of our stimuli and mask sequence, practice trial stimuli, and lack of feedback throughout the task. Schell's (2009) research is widely cited among literature on Tall Man lettering and found that Tall Man lettering resulted in the most amount of errors overall and the most false alarm errors when compared to no enhancements (lowercase) and color based enhancements. Another strength of our study is that it is the first to test the position of Tall Man letters with a drug name to our knowledge. Considering the various results in the Tall Man literature, it was important to try and look at this methodology in a new way.

Limitations of the Present Study

There were also several limitations to the current study that should be discussed. First, the FDA and ISMP Lists of Look-Alike Drug Names with Recommended Tall Man Letters (2011) recommends the use of bolded Tall Man letters. We were originally going to implement this, however the Inquisit software did not provide a simple way for doing this so it was omitted. Second, it was conducted in a laboratory that is quite different from healthcare environment in which Tall Man lettering is used. Participants had the benefit of a quiet, undisturbed environment and were free of distractions. Third, our sample consisted only of undergraduate college students that are younger than the average healthcare professional and lack the working knowledge of these drug names. Moving forward it would be beneficial to test this in a larger, more diverse sample to include pharmacy personnel and other healthcare professionals.

Conclusions and Future Prospects

Tall Man lettering should continue to be studied to understand if it really helps to distinguish confusable drug names and if so what is the mechanism for its efficacy. If the research continues to show null or very mixed results it might be worth taking a second look at the implementation of Tall Man lettering.

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APPENDIX A

STUDY INSTRUCTIONS

"In this study you will be asked to indicate if two drug names are different or the same. An asterisk (*) will appear, followed by the first drug name, a row of xxxxxxxx, and then the second drug will be presented.

Put your middle or index fingers on the E and I keys. When pairs of drugs are presented, press E if the two drugs are different and I if they are the same. GO AS FAST AS YOU CAN while making as few mistakes as possible.

Going too slow or making too many errors will result in an uninterpretable score."

APPENDIX B

DEBRIEF

Thank you for your participation in today's study. We are interested in understanding the effect of text enhancements, such as Tall Man lettering, on differentiating similar prescription drug names. Previous research has been conducted with mixed results (Schell, 2008; Darker, Gerret, Filik, Purdy, & Gale, 2011; Zhong, Feinstein, Patel, Dai, & Feudtner, 2015). This study aims to expand on the current literature and contribute new findings that will ultimately aid in better differentiation of similar drug names. Medical errors, to include drug name errors, are now the third leading cause of death in the United States, killing 251,000 people each year (Makary & Daniel, 2016). Thus, it is important to understand why these errors continue and identify ways to successfully differentiate confusable drug names.

All of the information collected in today's study will be confidential, and there will be no way of identifying your individual responses in the data archive.
We are not interested in any one individual's responses; we are looking for general patterns that emerge with the aggregated data. Your participation today is appreciated and will help human factors engineers and designers to present prescription drug names in ways that are more easily distinguished from other similar names. We ask that you do not discuss the nature of the study with others who may later participate in it, as this could affect the validity of our research conclusions.

If you have any questions concerning the research study, please contact the research team at: Ashley.Knobloch@asu.edu or Russel.Branaghan@asu.edu.
If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects

Institutional Review Board, through the ASU Office of Research Integrity and Assurance, at (480) 965-6788.

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APPENDIX C

STIMULI LIST

Beginning	
DOPamine	DOBUTamine
DAUNOrubicin	DOXOrubicin
TOLBUTamide	TOLAZamide
CISplatin	**CARBOplatin**
IDArubicin	**DOXOrubicin***
FLUoxetine	**DULoxetine**
DULoxetine	**PARoxetine**
FLUoxetine	**PARoxetine**
PHENobarbital	**PENTobarbital**

Middle	
vinCRIStine	vinBLAStine
cloZAPine	**cloNIDine**
rifAXIMin	**rifAMPin**
hydrALAzine (hydrALAZINE)*	**hydrOXYzine***
methylTESTOSTERone	methylPREDNISOLone (methylPREDNISolone)
niCARDipine (niCARdipine)*	**niMODipine**
azaTHIOPRine (azaTHIOprine)	**azaCITIDine**
lamOTRIGine (lamoTRIgine)	**lamIVUDine (lamiVUDine)**
sulfaSALAzine	**sulfadDIAzine (sulfADIAZINE)***

End	
chlorproPAMIDE	**chlorproMAZINE***
clomiPRAMINE	clomiPHENE
cycloSERINE	cycloSPORINE
metRONIDAZOLE (metroNIDAZOLE)	metFORMIN
metyrOSINE (metyroSINE)	**metyrAPONE (metyraPONE)**
mitoXANTRONE*	mitoMYCIN (mitoMYcin)
oxyMORPHONE (oxyMORphone)	**oxyCODONE**
romiPLOSTIM (romiPLOStim)	**romiDEPSIN (romiDEPsin)**
quiNINE	**quiNIDINE (quiNIDine)**

(Original Tall Man lettering recommendation)
Table 1. FDA–Approved List of Generic Drug Names with Tall Man Letters
Table 2. ISMP List of Additional Drug Names with Tall Man Letters***

(Original Tall Man lettering recommendation) Drug names in Bold with asterisk* denotes they are in Both Tables

Stimuli List

All Stimuli were taken from the FDA and ISMP Lists of Look-Alike Drug Names with Recommended Tall Man Letters (2016). This list can be accessed at: https://www.ismp.org/Tools/tallmanletters.pdf

APPENDIX D

WILD TALL MAN FORMAT

azaTHIOprine	aziTHROmycin
carBAMAZepine	carBIMazole
cefACLOR	cefADROXIL
cefALEXIN	cefTRIAZONE
cefIXime	cefOTAXime
cefTAZIDime	cefUROXime
clomiFENE	clomiPRAMINE
Depo-MEDRONE	Depo-PROVERA
diPYRIDAMOLE	diSOPYRAMIDE
DOPamine	DOBUTamine
foliC acid	foliNIC acid
gliCLAzide	glipiZIDE
mercaptAMINE	mercaptOPURINE
NICARdipine N	IFEdipine
peniciLLAMINE	peniciLLIN
PregABALIN	PregADAY
RifADIN	RifINAH
vinBLAStine	vinCRIStine
ZoFRAN	ZoTON
zoLPIDEM	zoPICLONE

List reproduced from (Darker, Gerret, Filik, Purdy & Gale, 2011)

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